

## **Indicator: Blood Cadmium Level (101)**

Elemental cadmium is a metal that is usually found in nature combined with other elements such as oxygen, chlorine, or sulfur. Cadmium enters the environment from the weathering of rocks and minerals that contain cadmium. Exposure to cadmium can occur in occupations such as mining or electroplating, where cadmium is produced or used. Cadmium exposure can also occur from exposure to cigarette smoke (CDC, 2003).

Cadmium and its compounds are toxic to humans and animals. Once absorbed into the human body, cadmium can accumulate in the kidneys and remain in the body for decades. Chronic exposure to cadmium may result in serious kidney damage. Osteomalacia, a bone disorder similar to rickets, is also associated with long-term ingestion of cadmium. Acute airborne exposure, as occurs from welding on cadmium-alloy metals, can result in swelling (edema) and scarring (fibrosis) of the lungs (CDC, 2003).

This indicator reflects blood cadmium concentrations in  $\mu\text{g/L}$  for the United States population, aged one year and older, as measured in the 1999-2000 National Health and Nutrition Examination Survey (NHANES). NHANES is a series of surveys conducted by CDC's National Center for Health Statistics (NCHS) that is designed to collect data on the health and nutritional status of the civilian, non-institutionalized U.S. population using a complex, stratified, multistage, probability-cluster design. Beginning in 1999, NHANES became a continuous and annual national survey; biomonitoring for certain environmental chemicals also was implemented. These data are presented here as a baseline with the intent of reporting trends in the future.

### **What the Data Show**

Table 101Cadmium presents the geometric means for blood cadmium among participants aged 1 year and older from NHANES 1999-2000. The overall geometric mean was  $0.4 \mu\text{g/L}$ . The blood cadmium measurements were similar among males and females as well as among the racial or ethnic groups sampled. The overall geometric mean among participants aged 20 years or older was slightly higher ( $0.5 \mu\text{g/L}$ ) than the geometric mean among the 12–19 year age group ( $0.3 \mu\text{g/L}$ ). Approximately one-half of all participants under the age of 12 had non-detectable blood cadmium concentrations.

### **Indicator Limitations**

- NHANES selects a representative sample of the civilian, non-institutionalized population in the United States using a complex, stratified, multistage, probability-cluster design. Beginning in 1999, NHANES became a continuous and annual national survey. With only 2 years of data in NHANES 1999-2000, instead of the 6-years for NHANES III (1988-1994), some differences exist that may limit the underlying data with respect to completeness or representativeness of coverage.
  - The sample size is smaller and the number of geographic units in the sample is more limited. The current 1999-2000 NHANES survey is nationally representative but it is subject to the limits of increased sampling error due to (1) the smaller number of individuals sampled in the annual sample and (2) the smaller number of Primary Sampling Units (PSUs) [see description below] available for each annual sample. Therefore, the sample size for any 1-year period is relatively small, possibly resulting in large variability for U.S. population estimates, especially those for narrowly defined demographic groups or other specific subgroup analyses.

- For NHANES 1999-2000, the first stage of selection was the PSU-level. The PSUs were defined as single counties. For a few PSUs, the county population was too small and those counties were combined with geographically contiguous counties to form a PSU. The 1999-2000 NHANES sample is selected from a relatively small number of PSUs compared to NHANES III. With a small number of PSUs, variance estimates that account for the complex design may be relatively unstable, a factor which introduces a higher level of uncertainty in the annual estimates.
- NHANES is designed to increase precision by combining data across calendar years. Because of the relatively small sample size in 1999 and 2000, analytical data for just one or two survey participants may be weighted heavily and greatly influence the mean value reported.
- The number of geographic sites sampled each year is small and environmental exposures may vary geographically; thus producing environmental exposure estimates by geographic region using the NHANES data set is of limited value.
- The measurement of cadmium or any other environmental chemical in a person's blood or urine does not by itself mean that the chemical has caused or will cause harmful effects.

### **Data Sources**

Centers for Disease Control and Prevention (CDC). 2003. Second National Report on Human Exposure to Environmental Chemicals. (Accessed November 21, 2004)  
<http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf>

### **References**

Centers for Disease Control and Prevention (CDC). 2003. Second National Report on Human Exposure to Environmental Chemicals. (Accessed November 21, 2004)  
<http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf>

## Graphics

Table 101Cadmium. Geometric mean and selected percentiles of blood cadmium concentrations (in µg/L) for the United States population, aged one year and older, by select demographic groups, National Health and Nutrition Examination Survey (NHANES), 1999-2000.

	Sample Size	Geometric Mean	10 <sup>th</sup>	25 <sup>th</sup>	50 <sup>th</sup>	75 <sup>th</sup>	90 <sup>th</sup>
Total, Age 1 year and older	7,970	0.4	<LOD	<LOD	0.3	0.6	1.0
Sex							
Male	3,913	0.4	<LOD	<LOD	0.4	0.6	1.0
Female	4,057	0.4	<LOD	<LOD	0.3	0.6	1.0
Race Ethnicity*							
Black, non-Hispanic	1,842	0.4	<LOD	<LOD	0.3	0.6	1.0
Mexican American	2,743	0.4	<LOD	<LOD	0.4	0.4	0.7
White, non-Hispanic	2,715	0.4	<LOD	<LOD	0.4	0.5	1.0
Age Group							
1-5 years	723	NC	<LOD	<LOD	<LOD	0.3	0.3
6-11 years	905	NC	<LOD	<LOD	<LOD	0.3	0.4
12-19 years	2,135	0.3	<LOD	<LOD	0.3	0.3	0.8
20+ years	4,207	0.5	<LOD	<LOD	0.4	0.6	1.0

\*Other racial/ethnic groups are included in the Total only

NC = Not Calculated — The proportion of results below the limit of detection was too high to provide a valid result

<LOD= Less than the limit of detection of the analytical method.

Source: Centers for Disease Control and Prevention. Second National Report on Human Exposure to Environmental Chemicals. January 2003. (Accessed November 21, 2004)

<http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf>

## **R.O.E. Indicator QA/QC**

**Data Set Name:** BLOOD CADMIUM LEVEL

**Indicator Number:** 101 (89100)

**Data Set Source:** CDC- NHANES

**Data Collection Date:** ongoing

**Data Collection Frequency:** 2 year cycle

**Data Set Description:** Blood Cadmium Level

**Primary ROE Question:** What are the trends in biomeasures of exposure to common environmental pollutants including across population subgroups and geographic regions?

### **Question/Response**

**T1Q1** Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Blood samples were collected and processed in accordance with the methods indicated in the NHANES Specimen Collection and Laboratory/Medical Technologists Procedures Manual (LPM). See: <http://www.cdc.gov/nchs/data/nhanes/blood.pdf> <http://www.cdc.gov/nchs/data/nhanes/LAB1-6.pdf> Cadmium and lead were simultaneously measured in whole blood. Cadmium and lead quantification is based on the measurement of light absorbed at 228.8 nm and 283.3 nm, respectively, by ground state atoms of cadmium and lead from either an electrodeless discharge lamp (EDL) or hollow cathode lamp (HCL) source. Human blood (patient or study) samples, bovine blood quality control pools, and aqueous standards are diluted with a matrix modifier (nitric acid, Triton X-100, and ammonium phosphate). The cadmium and lead contents are determined on a Perkin-Elmer Model SIMAA 6000 simultaneous multi-element atomic absorption spectrometer with Zeeman Background correction. See: [http://www.cdc.gov/nchs/data/nhanes/frequency/lab06\\_doc.pdf](http://www.cdc.gov/nchs/data/nhanes/frequency/lab06_doc.pdf) The units used for this indicator were  $\mu\text{g/L}$ . <http://www.cdc.gov/nchs/data/nhanes/frequency/varlab.pdf>

**T1Q2** Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. NHANES is designed to provide statistically representative national averages. Starting with NHANES 1999, the survey is conducted annually. All participants aged 1 year or older in NHANES 1999-2000 were measured for blood cadmium. The measurements produced by NHANES for this indicator were used in the “Second National Report on Human Exposure to Environmental Chemicals” published by the National Center for Environmental Health in 2003. <http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf>

**T1Q3** Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Not applicable.

**T2Q1** To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

This indicator is based on a national probability-based sampling design and is deemed of sufficient quality for generalization to the nation. The samples for 1999-2000 were used for this analysis. Quality assurance measures were in place. Beginning in 1999, NHANES became a

continuous and annual survey. The sampling plan for each year follows a complex, stratified, multistage, probability-cluster design to select a representative sample of the civilian, noninstitutionalized population. The 1999 NHANES was conducted in 12 counties across the U.S. From these locations, 5,325 people were selected to participate in the survey. Of these, 3,812 (71%) participated in the examination component. Data collection ended in 2000.

**T2Q2** To what extent does the sampling design represent sensitive populations or ecosystems?

The current sampling design includes oversampling of African Americans, Mexican Americans, adolescents (12-19 year olds), older Americans (60 years of age and older), and pregnant women to produce more reliable estimates for these groups.

**T2Q3** Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

This indicator simply provides information that exposure to cadmium has occurred. The measurement of cadmium or any other environmental chemical in a person's blood or urine does not by itself mean that the chemical has caused or will cause harmful effects. OSHA (1998) has developed criteria for evaluating occupational exposures. These occupational criteria are to be used to assess chronic workplace exposure. The criterion for blood cadmium is 5 ug/L. Occupational criteria are provided for comparisons only, not to imply a safety level for general population exposure. As reported in "Second National Report on Human Exposure to Environmental Chemicals" published by the National Center for Environmental Health in 2003. <http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf>

**T3Q1** What documentation clearly and completely describes the underlying sampling and analytical procedures used?

Documentation for NHANES 1999-2000 is found on NCHS/CDC website at the following URL: [http://www.cdc.gov/nchs/about/major/nhanes/nhanes99\\_00.htm#Laboratory%20Files](http://www.cdc.gov/nchs/about/major/nhanes/nhanes99_00.htm#Laboratory%20Files) The following provides more specific examples: The Addendum to the NHANES III for the 1999-2000 dataset clearly outlines the 1999-2000 sampling design and recommends analytic procedures. <http://www.cdc.gov/nchs/data/nhanes/guidelines1.pdf> <http://www.cdc.gov/nchs/data/nhanes/nhanes3/nh3gui.pdf> The "Second National Report on Human Exposure to Environmental Chemicals" published by the National Center for Environmental Health in 2003 more generally describes the NHANES 1999-2000 sampling plan. <http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf> Laboratory measurement information: [http://www.cdc.gov/nchs/data/nhanes/frequency/lab06\\_doc.pdf](http://www.cdc.gov/nchs/data/nhanes/frequency/lab06_doc.pdf) And the "Weighting Notes" posted on the NHANES website also offer helpful advice. <http://www.cdc.gov/nchs/data/nhanes/frequency/weights%20to%20usev6.pdf>

**T3Q2** Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

For the most part, Individual level data are available, but data access limitations do exist for some variables due to confidentiality issues.

[http://www.cdc.gov/nchs/about/major/nhanes/nhanes99\\_00.htm#Laboratory%20Files](http://www.cdc.gov/nchs/about/major/nhanes/nhanes99_00.htm#Laboratory%20Files)

**T3Q3** Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes. The Addendum to the NHANES III for the 1999-2000 dataset clearly outlines the 1999-2000 sampling design and recommends analytic procedures.

<http://www.cdc.gov/nchs/data/nhanes/guidelines1.pdf>

<http://www.cdc.gov/nchs/data/nhanes/nhanes3/nh3gui.pdf>

**T3Q4** To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

The quality assurance plans for NHANES 1999-2000 are available from the Division of Data Dissemination, NCHS, 6525 Belcrest Rd. Hyattsville, MD, 20782-2003. Tel. 301-458-4636.

Internet: <http://www.cdc.gov/nchs/about/quality.htm>

**T4Q1** Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Yes. The NHANES 1999-2004 survey is designed to be annually nationally representative of the U.S. citizen, non-institutionalized population. (see page 11 of the addendum linked below)

<http://www.cdc.gov/nchs/data/nhanes/guidelines1.pdf>

**T4Q2** Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Yes. (see pages 11-19 of the addendum linked below)

<http://www.cdc.gov/nchs/data/nhanes/guidelines1.pdf>

**T4Q3** Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

NHANES selects a representative sample of the civilian, non-institutionalized population in the United States using a complex, stratified, multistage, probability-cluster design. Beginning in 1999, NHANES became a continuous and annual national survey. With only 2 years of data in NHANES 1999-2000, instead of the 6-years for NHANES III (1988-1994), some differences exist that may limit the underlying data with respect to completeness or representative of coverage. The sample size is smaller and the number of geographic units in the sample is more limited. The current 1999-2000 NHANES survey is nationally representative but it is subject to the limits of increased sampling error due to (1) the smaller number of individuals sampled in the annual sample and (2) the smaller number of Primary Sampling Units (PSUs) [see description below] available for each annual sample. Therefore, the sample size for any 1-year period is relatively small, possibly resulting in large variability for U.S. population estimates, especially those for narrowly defined demographic groups or other specific subgroup analyses. For NHANES 1999-2000, the first stage of selection was the PSU-level. The PSUs were defined as single counties. For a few PSUs, the county population was too small and those counties were combined with geographically contiguous counties to form a PSU. The 1999-2000 NHANES sample is selected from a relatively small number of PSUs compared to NHANES III. With a small number of PSUs, variance estimates that account for the complex design may be relatively unstable, a factor which introduces a higher level of uncertainty in the annual estimates. NHANES is designed to increase precision by combining data across calendar years. Because of the relatively small sample size in 1999 and 2000, analytical data for just one or two survey participants may be weighted heavily and greatly influence the mean value reported. The number of geographic sites sampled each year is small and environmental exposures may vary

geographically; thus producing environmental exposure estimates by geographic region using the NHANES data set is of limited value. For more information, see the addendum to NHANES III linked below: <http://www.cdc.gov/nchs/data/nhanes/guidelines1.pdf>

**T4Q4** Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

As subsequent years are added to this survey, estimates will become more stable. However, with the laboratory data, there is no guarantee that an environmental chemical will be measured from year to year. Although the annual NHANES is nationally representative, it is not possible to produce environmental exposure estimates by geographic region. Because the number of geographic sites sampled each year is small and because environmental exposure measures may vary geographically, national estimates based on one year of data may be highly variable. Serum cadmium was measured in all people aged one year and older. The measurement of cadmium or any other environmental chemical in a person's blood or urine does not by itself mean that the chemical has caused or will cause harmful effects